

Development of high-accuracy Image-Guided Radiation Therapy Equipment with compact C-band accelerator



Etsuro Hirai^{*1}



Yuichiro Kamino^{*2}



Masahiro Hiraok



Masaki Kokubo^{*4}

1. OUTLINE

The importance of “Radiation Therapy” for cancer treatment has been remarkably increasing in these days, along with Surgical Therapy and Chemotherapy, because of its noninvasiveness and economic efficiency, which meet the demand of our rapidly aging society.

The equipment, MHI-TM2000, enabled the easy, quick (highly-efficient), and exact (highly-accurate) radiation therapy by integrating:

1) highly-accurate targeting mechanism (Gimbals mechanism), 2) compact X-ray generator (C-band accelerator), and 3) image-guided function (3D reconstruction with stereo X-ray images, with 2 imagers)

2. TECHNOLOGIES

Refer to the Figure 1 on the right, “Appearance of TM2000”, and Figure 2, “Basic structure of TM2000”. The significant characteristics are:

[1] **O-ring type gantry:** Adopted high-rigid and O-ring-shaped gantry for the platform. The rigidity and shape allowed to minimize gantry deformation/sag by gravity, etc., and achieved highly accurate irradiation targeting.

Once a patient is positioned on couch, matching his/her diseased area to the isocenter, O-ring and/or whole gantry, rather than patient or couch, rotates and irradiation becomes enable from any angle to all around of patient’s body. (See Fig. 2)

[2] **C-band standing-wave type accelerator:** To reduce in size and weight of accelerator, we adopted the accelerator, which has double frequency (5.712GHz) and one third of weight compared with existing ones. The lighter accelerator allowed us to make lighter X-ray head and accomplish the world’s first oscillating targeting mechanism. (See [3] below). Beam-output stability is kept secured with our self-developed “Optimum frequency control system”, which adjusts acceleration frequency depending on minute heat expansions during operating accelerator. (See Fig. 3)

[3] **Gimbals-supported X-ray head:** Installed the oscillating targeting mechanism, called “gimbals mechanism” on X-ray head, which generate treatment X-ray, and installed accelerator on the gimbals mechanism. This mechanism can correct minute elastic deflection of Gantry, arbitrarily select X-ray targeting directions, and allow us to successfully achieved ± 0.1 mm irradiation accuracy. (See Fig. 4)

[4] **Two kV X-ray imaging systems:** Installed two sets of imaging systems. They can take patient’s stereo-static images from any angle, and the images facilitate users to visually observe and verify the position of intra-tumor, just before treatment. In addition, cone-beam CT images can be taken, in a short time, using and rotating either one set of the two imaging systems, and they also facilitate users to visually observe not only intra-bone structures but also intra-soft tissues. These functions have dramatically improved the reliability of X-ray irradiation and radiation therapy.

3. MARKETING AND FURTHER DEVELOPMENT

This high-accuracy Image-Guided Radiation Therapy Equipment, MHI-TM2000, has been cleared by U.S. Food Drug Administration (FDA) and Japan Ministry of Health, Labour and Welfare, for marketing, and has received type approval.

The equipment was brought into the market first in April, 2008 and has been applied to clinical treatments at Institute of Biomedical Research and Investigation, in Kobe, Japan. We are willing to continue to do our best and develop the functions/products to meet patients’, phisicians’ and radiological technologists’ needs, like “Dynamic tracking irradiation” for moving tumor, and market them to contribute to the society.

^{*1} Mitsubishi Heavy Industries, Ltd.
(4-6-22 Kan-on-shin-machi, Nishi-ku, Hiroshima 733-8553 JAPAN)
^{*2} Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems Works
(10 Ohe-cho, Minato-ku, Nagoya-shi, Aichi 455-8515 JAPAN)
^{*3} Graduate school of Medicine and Faculty of Medicine, Kyoto University
(54 Kawahara-cho, Shogo-in, Sakyo-ku, Kyoto 606-8507 JAPAN)
^{*4} Institute of Biomedical Research and Innovation
(2-2 Minatojima-minamimachi, Chuo-ku, Kobe 650-0047 Japan)

Fig.1 Appearance of MHI-TM2000



Fig. 2 Basic structure of MHI-TM2000



Fig. 3 Structure of the compact c-band accelerator

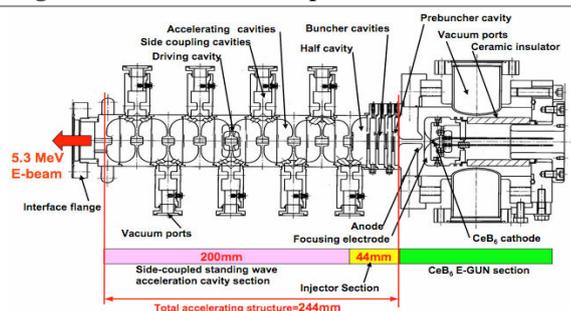


Fig. 4 Oscillating X-ray head by gimbals mechanism

